

CHAPTER 2: HYDROLOGY

BACKGROUND

United States Geological Survey (USGS) flow records for the San Juan River begin in 1911, but are not consistent or complete until about 1929. By this time substantial irrigation development had occurred. While the pre-Navajo Dam hydrology is natural in shape, it is depleted in volume by about 16 percent from natural conditions due to this irrigation development, with most of the depletion coming during the summer months. Since the depletion prior to Navajo Dam was relatively small and the flow was not regulated by major storage reservoirs, the conditions during the pre-dam period (1929-1961) are used to judge effects of later development and the value of future modification of the hydrology for the benefit of the endangered fishes.

Daily flow data recorded by the USGS (Hydrosphere 1999) from 1929 through the present are available for the key points on the San Juan River. These data have been used to analyze the 1999 hydrology and compare the statistics to other years. The foundation of comparison are the flow statistics in the SJRIP Flow Recommendation Report (Holden, 1999).

METHODS

Beginning in 1999, the operating rules recommended in the Flow Recommendation Report have been employed by Reclamation as far as restrictions would allow. Presently, the only restriction is to the minimum release from Navajo Dam, which cannot fall below 500 cfs until an Environmental Impact Statement (EIS) is completed. USGS gage records were used to assess the resulting hydrograph at Archuleta, Farmington, Shiprock, Four Corners and Bluff.

For each release year, the operating rules are evaluated utilizing the anticipated water supply and the release criteria set. The design release pattern and the actual releases are compared. The statistics of each year are computed and the flow recommendation conditions that were met indicated.

RESULTS

Research releases from Navajo Dam were made every year from 1992 through 1998 (1991 was a control year with no modification to the release) to augment the unregulated flows from the Animas River and provide peak spring runoff flows mimicking a natural hydrograph in the San Juan River below Farmington, NM. Beginning in 1999, the operating rules presented in the Flow Recommendation Report were implemented. The fall of 1998 was identified as a perturbation year, calling for a minimum release of 114,000 af with a 1 week ramp up, one-week peak and one-week ramp down. Table 2.1 describes the nature of the release each year since 1991. The volume of water released in excess of an assumed base release of 600 cfs normally required to meet downstream demands is also shown. The volume released exceeded the minimum required by about 52,000 af.

Table 2.1. Summary of Navajo Dam release hydrograph characteristics since the beginning of the research period, 1992 to 1999.

YEAR	ASCENDING LIMB	PEAK	DESCENDING LIMB	MATCHED ANIMAS RIVER PEAK	VOLUME ABOVE 600 CFS BASE - AF
1992	6 weeks starting April 13	2 weeks at 4,500 cfs	4 weeks ending July 15	Yes	409,740
1993	Starting March 1, rapid increase to 4,500 (compare with 1987)	split peak, 45 days at 4,500 cfs, 7 days at 4,500 cfs	4 weeks ending July 13	No	773,820
1994	4 weeks starting April 23	3 weeks at 4,500 cfs	6 weeks ending July 28	Yes	486,620
1995	3 weeks at 2,000 cfs in March, ramp to 4,500 over 6 weeks starting April 1	3 weeks at 5,000 cfs	4 weeks ending July 14 (summer flow increased by 200 cfs)	Yes	675,810
1996	1 week starting May 27	3 weeks at 2,500 cfs	1 week ending June 29	No	100,320
1997	3 weeks at 2,000 cfs in March, return to 600-cfs base for 31 days, 10 days starting May 12	2 weeks at 5,000 cfs	6 weeks ending July 16	Yes	433,580
1998	30 days starting April 23	3 weeks at 5,000 cfs	1 week ending June 18	Yes	340,850
1999	9 days starting May 24	8 days at 5000 cfs	9 days ending June 18	No	166,189

To fit operational requirements at the dam, the ramp up, peak and ramp down were all slightly longer than required, resulting in a larger release, placing the actual release closer to the intermediate release shown in the operation rule tree of the Flow Recommendation Report.

Table 2.2 compares the flow statistics from 1999 to those of the 1992-1998 period for each category identified in the Flow Recommendation Report. Also indicated are the desired conditions that were met. With the exception of average base flow, all flow conditions were met.

The 1999 hydrographs for the San Juan River at Archuleta (release hydrograph) and at Four Corners are presented in Figure 2.1. Inflows into Navajo Dam were much greater than normal during the summer of 1999, resulting in a large release from Navajo Dam to prevent spill and provide space to prevent a further spill later in the year. This summer release was the decision of Reclamation and was not the recommendation of the Biology Committee, although the Biology Committee was informed that the release would take place.

The hydrographs at Four Corners for these years appear in Figures 2.2 and 2.3. The flow statistics that apply to these hydrographs appear in Table 2.3. The Four Corners gage is considered the most representative gage for the habitat range and is used in all correlations reported here.

Table 2.2. Flow Statistics met in each year

Flow Condition	Std	1992	1993	1994	1995	1996	1997	1998	1999
Days at 10,000 cfs or more	5	0	1	0	11	0	10	0	0
Days at 8,000 cfs or more	10	3	16	13	27	0	33	2	0
Days at 5,000 cfs or more	21	54	109	49	72	0	50	34	29
Days at 2,500 cfs or more	10	81	128	67	135	36	100	65	70
Yrs w/o meeting 10,000cfs	10	6	7	8	0	1	0	1	2
Yrs w/o meeting 8,000 cfs	6	4	0	0	0	1	0	1	2
Yrs w/o meeting 5,000 cfs	4	0	0	0	0	1	0	0	0
Yrs w/o meeting 2,500 cfs	2	0	0	0	0	0	0	0	0

Note: Values in Bold are those that meet or exceed the minimum standard

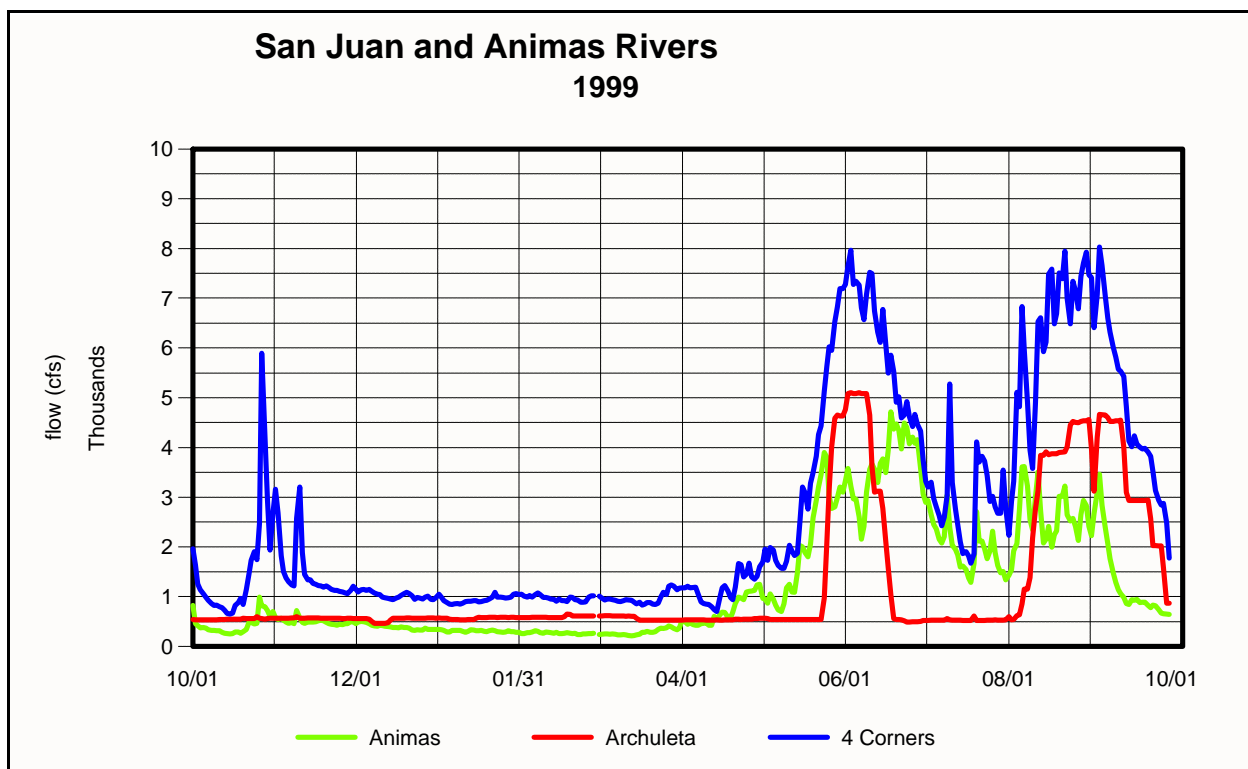


Figure 2.1. 1999 hydrographs for Animas River at Farmington, San Juan River at Archuleta and Four Corners.

Table 2.3. Summary of flows for the research (1991-1998) and monitoring (1999) periods, San Juan River at Four Corners, New Mexico.

	1991	1992	1993	1994	1995	1996	1997	1998	1999
San Juan River at Four Corners, New Mexico									
Peak Runoff-cfs	5,160	8,900	10,300	10,000	12,100	3,540	11,900	8,580	8,030
Runoff(Mar-Jul)-af	599,459	1,074,795	1,714,328	1,039,601	1,624,927	431,913	1,338,539	931,106	876,846
Runoff(total annual)-af	1,086,676	1,512,795	2,216,819	1,448,893	2,102,228	815,795	1,844,019	1,401,536	1,901,803
Peak Date	16-May	29-May	03-Jun	05-Jun	19-Jun	18-May	04-Jun	04-Jun	03-Jun
Days>10,000	0	0	1	0	11	0	10	0	0
Days>8,000	0	3	16	13	27	0	33	2	0
Days>5,000	2	54	109	49	72	0	50	34	29
Days>2,500	46	81	128	67	135	36	100	65	70
Ave. Daily Flow for month									
October	1,449	769	827	941	1,109	1,091	1,276	1,404	1,533
November	1,127	1,356	911	1,210	1,077	1,139	883	1,175	1,494
December	1,080	1,088	957	1,105	960	1,088	702	1,154	1,031
January	1,173	859	1,358	1,050	918	785	789	1,208	947
February	1,289	1,298	1,511	781	1,076	899	690	1,239	976
March	995	1,173	5,463	967	2,782	766	2,255	1,267	969
April	1,810	3,723	6,188	1,028	3,478	607	2,529	1,910	1,174
May	3,739	6,634	7,298	5,251	6,119	2,150	6,000	5,831	3,439
June	2,580	4,844	7,701	7,836	9,367	2,925	8,514	4,542	5,986
July	801	1,444	1,776	2,170	5,187	715	2,904	1,802	2,925
August	556	927	1,348	552	1,564	492	2,310	1,073	6,135
September	1,441	997		1,142	1,193	891	2,365	574	4,852
Uniqueness		Control	early ave. storm @ spawn	early ascent	late ave.	late peak	dry	narrow runoff storm @ spawn	early ave. storm @ spawn

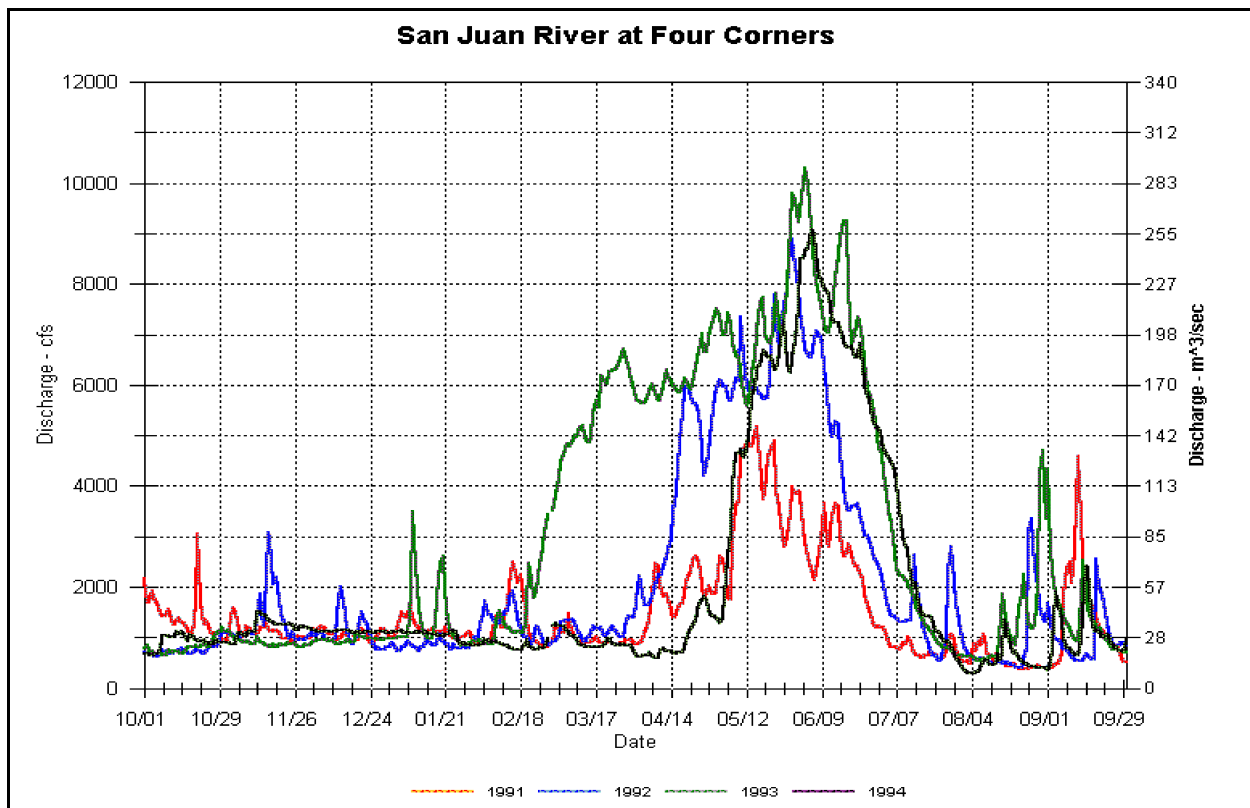


Figure 2.2. Hydrographs for the San Juan River at Four Corners for 1991 - 1994.

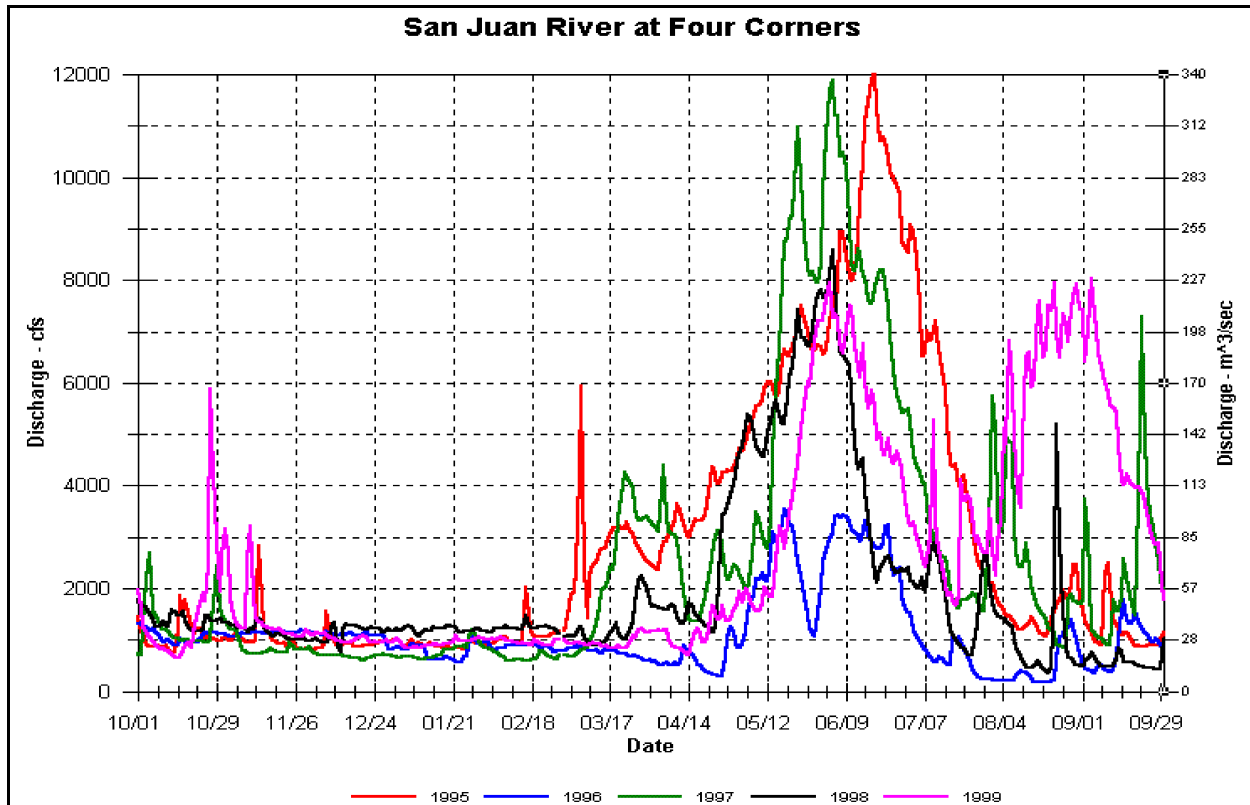


Figure 2.3. Hydrographs for the San Juan River at Four Corners for 1995 - 1999.

Storm Influence

The San Juan River is heavily influenced by high intensity summer and fall advective storms. These storms produce short duration flow increases that are heavily sediment laden and have been associated with deterioration of habitat quality in the San Juan River. The post-runoff season of 1999 was unusually wet. For most of August and half of September the flows at Four Corners were in excess of 5,000 cfs and peaked over 8,000 cfs.

In the Flow Recommendation Report (Holden, 1999), the conditions that impacted habitat quality were described, based on calibration to observed impacts from storm events. A storm-event day is defined as a day in which the daily gain in flow between Farmington, New Mexico and Bluff, Utah, and the daily flow at Bluff, Utah, were each more than 150 cfs greater than the 5-day average. A storm-event day was given a weight of 2 if the gain in flow was 3,000 cfs or more. A year in which there were more than 12 storm-event days between August 25 and the end of February was determined to be a year in which the backwater habitats were filled with sediment (perturbated) to the point that flushing was required to restore them. 1999 was considered a perturbated year using this standard. However, the flows were so high that some backwater flushing occurred, partially flushing the sediment that would normally accumulate. While substantial sediment filling occurred, it is less than would have been anticipated for the number of sediment flow days.